STIFFENED SUSPENSION BRIDGE APPLIED TO A SHORT SPAN

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Reprinted from
The Canadian Engineer
Toronto, Ont.

FOREWORD.

IN the following pages is described one of the smaller bridges, which were designed by our firm during the year 1910. Many situations exist where the stiffened suspension bridge could be used to advantage. However, it is not claimed that this type of bridge has a very wide application, but that the engineers have solved the particular problem that the situation presented in a satisfactory manner.

The case here presented and the manner of its solution affords an example of the fact that every bridge problem possesses individuality. In order to determine the most suitable form of bridge for a particular situation many local conditions should be considered. Amongst these are the nature of the foundations available, the kind of traffic the bridge will be required to bear, the price of materials at the bridge site, sand, gravel, etc., the height of the bridge from the water, whether the floor is to be level or on a grade, and many other things. The last-mentioned point, other things being equal, will often decide the case between steel and reinforced concrete.

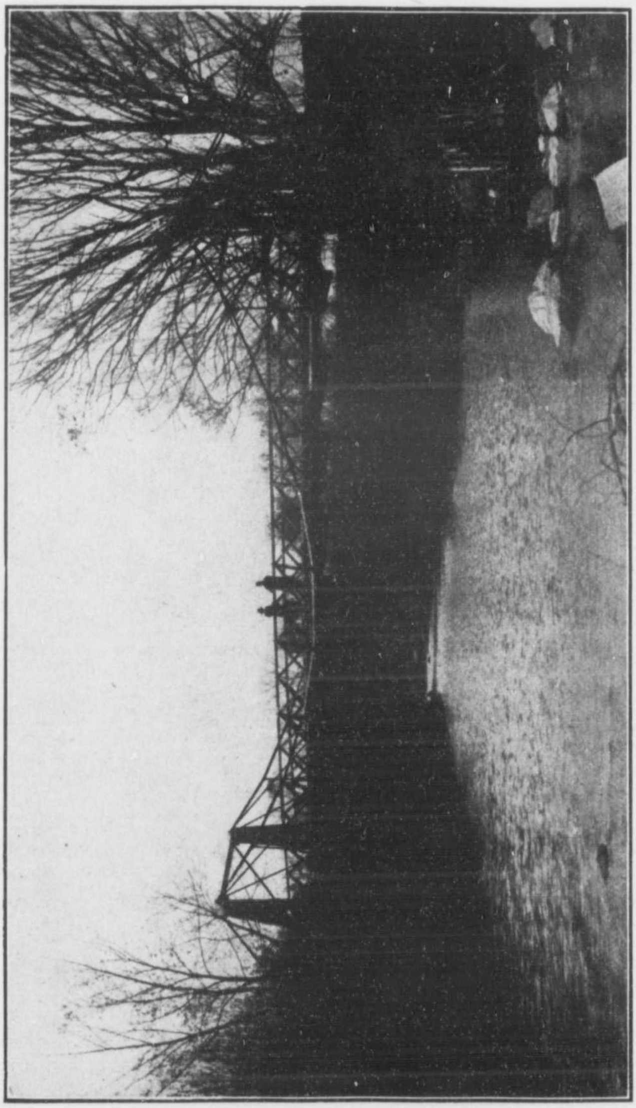
During the last few months our firm has had recourse to steel bridges of every description, including steel beam bridges, deck spans, through spans and pony trusses; reinforced concrete arches of many different designs, including what is at present the longest span arch in Canada, the Wadsworth bridge at Weston; and reinforced concrete girder and truss bridges or "flat tops" of many different kinds.

Although we design bridges and supervise their erection, we do not build bridges. As we are not connected in any way with contractors, and have no interest in one type of bridge over another, accurate comparative estimates from an unbiassed point of view are available to our clients, in order that they may decide upon the most suitable bridge for any situation.

We shall be pleased to send upon request to those interested a booklet describing some of our steel and reinforced concrete bridges.

BARBER & YOUNG.

January, 1911.



THE STIFFENED SUSPENSION BRIDGE APPLIED TO A SHORT SPAN.

Frank Barber.*

SUSPENSION bridges are universally admired for their singularly graceful lines. The tenuous webs of steel which cling to the towers and the long sweep of the slender cables embody the spirit of lightness and strength. The great bridges of this type, such as Brooklyn Bridge and the one which spans Niagara's gorge at Lewiston, are known to us all, but the comparatively short suspension bridge shown in our illustration is, perhaps, something of a novelty.

It is true that some cheap footbridges have been built on this plan, mostly consisting of wire fencing, with a plank for footing. But these have no stiffening trusses, and they sag to such an extent under a load that it requires an athlete to keep step with the vibrations and be able to cross them in safety.

The bridge here illustrated was built last summer over the River Don on the farm of Mr. George S. Henry, Oriole, York county, Ont., from designs furnished by and under the supervision of our firm.

It has a span of 90 feet, a roadway of 14 feet, and the floor is about 15 feet from low water. The wooden joists and floor beams were designed for a five-ton wagon, with a good safety factor, but while the timbers are sound they will safely carry an eight-ton traction engine. If at any time it should be found advisable to increase the capacity of the bridge for concentrated loads it could be done by strengthening the floor system, as the cables will support, besides the weight of the bridge, a live load of 15 tons with a safety factor of four.

The stiffening trusses are slightly heavier than the requirements as computed by the theory of the suspension bridge, and are supplemented by stay-rods radiating from the tops of the towers, or main posts, which

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bear the cables. Consequently under a heavy load there is no more vibration than there is on a steel truss bridge. The wind stresses are resisted by rod laterals with turnbuckles and by careful bracing at the ends of the bridge, the bracing being supported on concrete foundations.

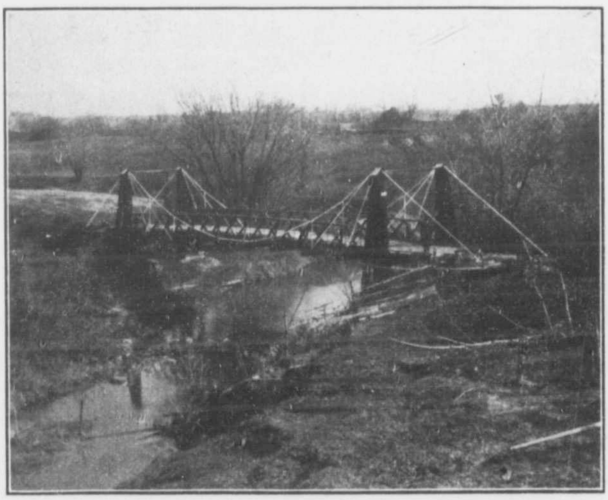
It is to be noticed that under a moving load each part of both upper and lower chords of the stiffening trusses is alternately in compression and tension. Consequently every joint in the chords must be carefully spliced for tension.

The cables have a dip of 15 feet in the main span of 90 feet, and 420 feet of cable was used in all. The main posts, over which the cables are hung, rest upon secure concrete foundations. The ends of the cables are

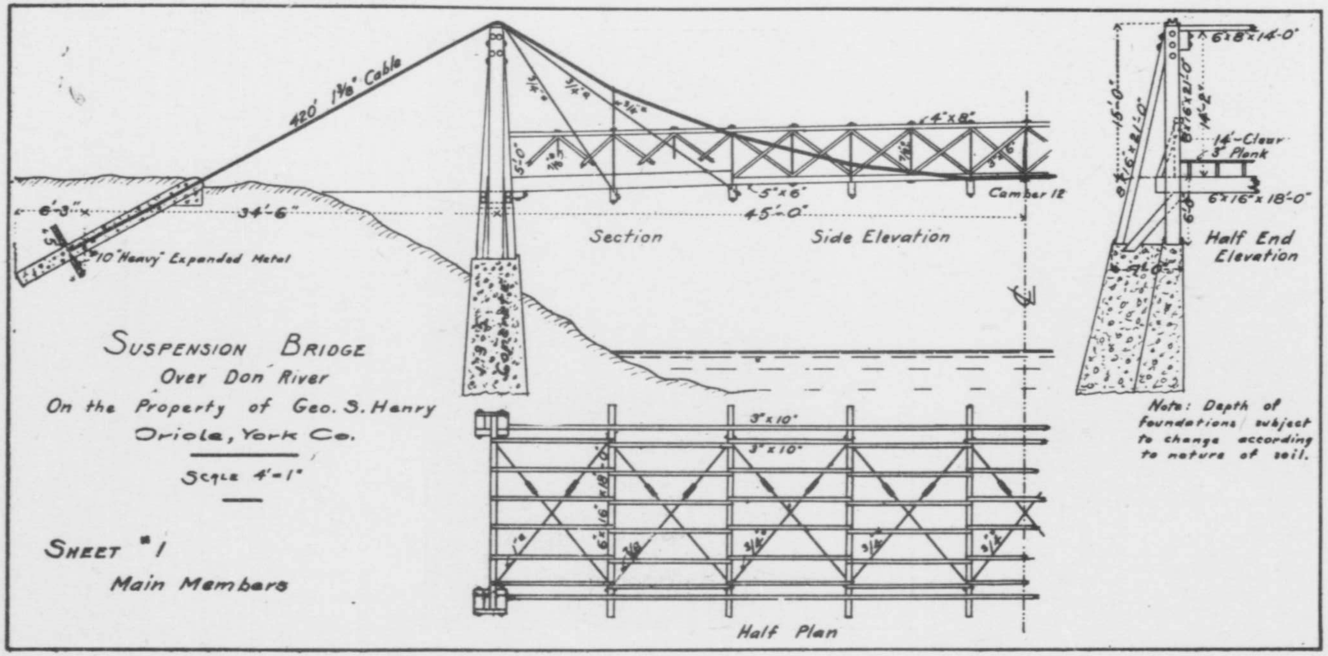
attached to concrete anchorages deeply embedded in the earth banks, and all the underground parts are protected by concrete. The cables are 1⅜-inch crucible cast-steel, galvanized, with steel centres. They are composed of seven strands of seven wires each. They were manufactured especially for suspension bridges by the Roeblings, Trenton, N.J.

It is interesting to note that John A. Roebling, the father of the present proprietors of this manufactory, was the engineer of Brooklyn Bridge, and he established this industry in order that the first great suspension bridges might be built.

Comparing the parts constructed of wood in the bridge here considered with an ordinary Howe truss wooden bridge, it is seen that in the suspension bridge it is convenient to place the floor-beams (or needle-beams) much closer together than is usual in a wooden or steel truss bridge, making it possible to use shorter joists, and consequently joists of smaller dimensions for equal strength. Here six joists of 3″ x 10″ x 10′ are used. This alone effects a considerable saving in the floor system while not reducing the strength. Secondly, in the case of a wooden bridge, no main truss member can be removed and replaced without causing the collapse of the bridge unless every needle-beam is supported independently from the bed of the stream. Consequently, when two or three truss members of a wooden bridge



become unsound it often condemns the whole bridge on account of the difficulty of replacing them. On the other hand, in our suspension bridge, since every needle-beam is hung from the cables any member of the stiffening trusses may be taken out and replaced without supporting or strengthening the remainder of the bridge. Thus one or two men may inspect this suspension bridge every few years, and may without trouble replace any unsound members. The comparatively small size of the members makes these repairs all the easier, the largest member being a 4″ x 8″, except for the needle-beams and the main posts.



420' 1 1/8" Cable
6'-3"
34'-6"
10" "Henry" Expanded Metal
4"x8"
5"x6"
45'-0"
Camber 12
Section
Side Elevation
3"x10"
3"x10"
Half Plan
6"x8"x14'-0"
15'-0"
14'-Clear
3" Plank
6"x16"x18'-0"
Half End
Elevation
Note: Depth of foundations subject to change according to nature of soil.
Suspension Bridge
Over Don River
On the Property of Geo. S. Henry
Oriole, York Co.
Scale 4'=1"
Sheet #1
Main Members

As the timbers become unsound from age and exposure to the weather these repairs will probably be strictly attended to, especially as this bridge is privately owned, and as it adds several thousand dollars in value to Mr. Henry's fine property. In the course of, perhaps, fifty years the whole of the woodwork will have been gradually replaced by new timber, except the main posts, which will probably be rebuilt in concrete. These occasional repairs to the timber will make the bridge last as long as its usefulness, since the other materials are permanent, the galvanized steel cables being almost as durable as the concrete foundations. It will be seen from the estimate of cost which follows that the cost for material and carpenters of replacing the whole of the timber once will be about $500—approximately one-half the total first cost of the bridge. Had the towers which carry the cables been built in concrete the cost of replacing the timber would be much less, as these heavy posts (21 feet long, three at each corner of the bridge, twelve in all) make up a large portion of the timber.

The cost of the bridge is partially itemized below:—

Cable	$110 00
Round rods (hangers, laterals, etc.)...	55 00
Four special castings	11 00
Nails, bolts, etc.	15 00
Blacksmithing	10 00
Portland cement	50 00
Lumber	400 00
Carpenter	100 00

Besides these items are engineering and unskilled labor. The latter is rather difficult to estimate in this case as Mr. Henry supplied the labor from his own farm hands during slack times on the farm. But a liberal estimate for labor will bring the total cost to less than $1,000, not including earth filling for the approaches.

From these figures it is seen that the suspension bridge is much cheaper than any other form of bridge for this situation. The cost is certainly less than one-half of that of an ordinary wooden bridge of the same span, and about the same as the cost of the cheapest kind of wooden bridge of 60 ft. span resting upon four piles at either end for abutments.

The very low cost of this bridge of course involves the wooden floor system, which is not suitable, and in the end is not economical, for constant and heavy traffic.

It is doubtful if this type of bridge could be built with great advantage for spans much less than that of the bridge here described. On the other hand, the advantage in low cost of the suspension bridge with wooden floor over all other types becomes more marked as the clear span of the bridge becomes greater. For a single span of 300 feet, for instance, the suspension bridge would be much cheaper than the common steel truss bridge with wooden floor and joists, and, if the stiffening trusses were made deep and strong enough, it would be equally rigid and more permanent. The same is true for intermediate and greater spans. A suspension bridge with wooden floor of 300 feet span is now being constructed at Lillooet, British Columbia, as the cheapest and best bridge for the kind of traffic it will have to bear.

We have not far to seek for the reason why recourse has not been had before to the suspension bridge for comparatively short spans, and why more of them have not been built in Canada for short as well as for longer spans. It is because of the peculiar situation which has existed in regard to bridge engineering and bridge building in this country. Buyers of bridges in Canada have been in the habit of going directly to the bridge companies, not only for their bridges, but for designs of bridges, and even for engineering advice (for this is involved in the system of calling for tenders with competitive designs), and they naturally have bought the only things which the bridge companies have to sell, namely, steel truss or beam bridges.

Summarizing the advantages of the suspension bridge, we have already noted low cost and durability, although the latter involves renewals of the wooden parts, and to these should be added great ease of erection, as no false work is required. The difficulties to be overcome and the care required have to do with design and engineering rather than with construction.